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Tullock Reservoir Calaveras and Tuolumne Counties, California

(U.S.) National Eutrophication Survey, Corvallis, OR

Prepared for

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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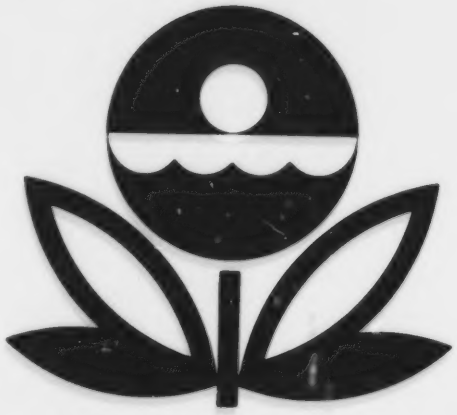

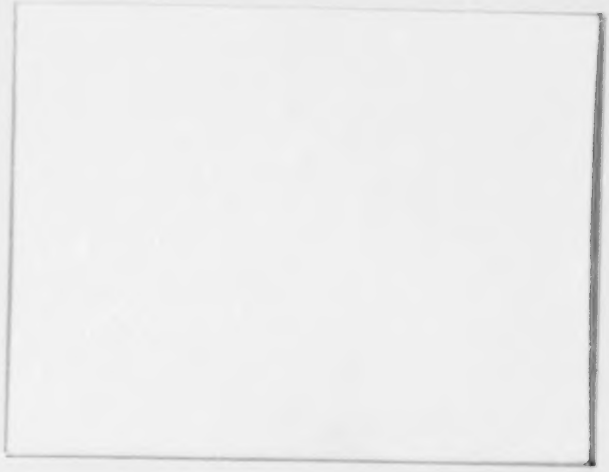

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REPORT
ON
TULLOCK RESERVOIR
CALAVERAS AND TUOLUMNE COUNTIES
CALIFORNIA

EPA REGION IX

WORKING PAPER No. 760

WITH THE COOPERATION OF THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

AND THE

CALIFORNIA NATIONAL GUARD

JUNE, 1978

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentration (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the California State Water Resources Control Board and the nine Regional Water Quality Control Boards for professional involvement, to the California National Guard for conducting the tributary sampling phase of the Survey, and to those California wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Division of Planning and Research of the State Water Resources Control Board provided invaluable lake documentation and counsel during the Survey, coordinated the reviews of the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

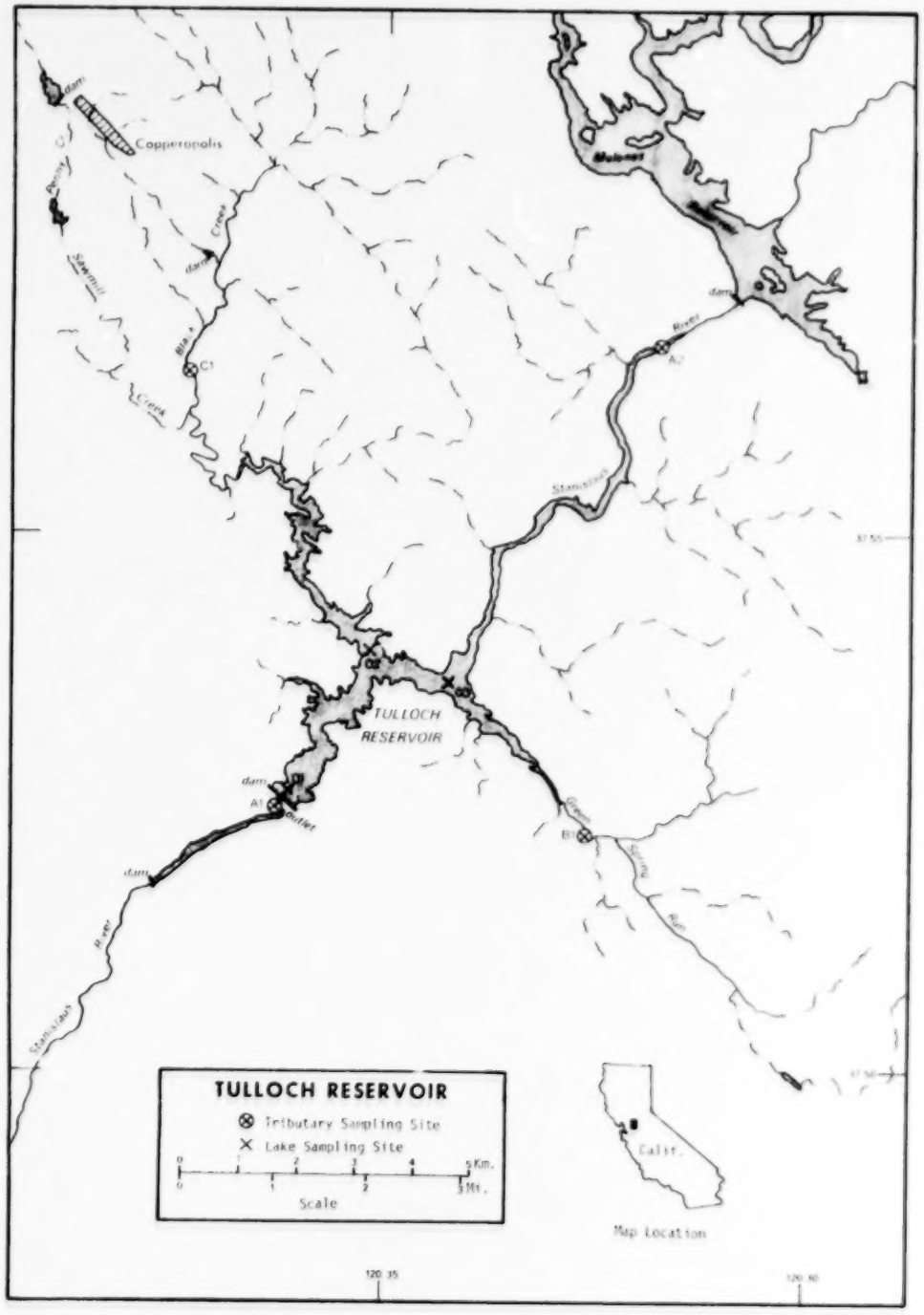
Major General Glen C. Ames, the Adjutant General of California, and Project Officer Second Lieutenant Terry L. Barrie, who directed the volunteer efforts of the California National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of California

Name	County
Amador	Amador
Boca	Nevada
Britton	Shasta
Casitas	Ventura
Crowley	Mono
Don Pedro	Tuolumne
Elsinore	Riverside
Fallen Leaf	El Dorado
Hennessey	Napa
Henshaw	San Diego
Iron Gate	Siskiyou
Lopez	San Luis Obispo
Mary	Mono
Mendocino	Mendocino
Nicasio	Marin
Lower Otay	San Diego
Pillsbury	Lake
Santa Margarita	San Luis Obispo
Shasta	Shasta
Shaver	Fresno
Silver	Mono
Tahoe	El Dorado, Placer, CA; Carson City, Douglas, Washoe, NV
Tulloch	Calaveras, Tuolumne
Lower Twin	Mono
Upper Twin	Mono


Copperopolis
dam
Penny Creek
Stanislaus River
dam
Black Creek
C1
Littlejohns Creek
dam
Rivett
A2
Stanislaus River
TULLOCH RESERVOIR
dam
A1
Outlet
dam
Stanislaus River
Carson Creek
B1
Curtis Creek
Rock Creek
TULLOCH RESERVOIR
Tributary Sampling Site
Lake Sampling Site
0 1 2 3 4 5 Km.
0 1 1 2 3 Mi.
Scale
Calif.
Map Location
120 35
120 30

TULLOCK RESERVOIR

STORET NO. 0624

I. CONCLUSIONS

A. Trophic Condition*:

Survey data indicate that Tullock Reservoir is eutrophic. It ranked eleventh in overall trophic quality when the 24 California lakes and reservoirs sampled in 1975 were compared using a combination of six parameters**. Eleven of the water bodies had less median total phosphorus, ten had less median dissolved orthophosphorus, nine had less and five had the same median inorganic nitrogen, 19 had less mean chlorophyll a, and 15 had greater mean Secchi disc transparency. Significant depression of dissolved oxygen with depth did not occur at any station or sampling time.

Survey limnologists did not observe macrophytes or surface concentrations of algae. However, the chlorophyll a concentration at station 3 in November (64.2 µg/l) indicates a possible bloom condition there at that time.

B. Rate-Limiting Nutrient:

Due to significant changes in nutrients in the samples during shipment from the field to the laboratory, the algal assay results are not considered representative of conditions in the reservoir at the times the samples were taken.

The reservoir data indicate nitrogen limitation in March and June and phosphorus limitation in November.

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* Trophic assessment is based on levels of nutrients, dissolved oxygen, and chlorophyll a; phytoplankton kinds and numbers; and transparency (Allum et al., 1977.

** See Appendix A.

C. Nutrient Controllability:

1. Point sources--No known municipal wastewater treatment plants impacted Tullock Reservoir during the sampling year. Septic tanks serving shoreline dwellings were estimated to have contributed 0.1% of the total phosphorus load, but a shoreline survey is needed to determine the significance of those sources.

The present phosphorus loading of 7.34 $g/m^2/yr$ is a little more than twice that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). However, the mean hydraulic retention time of the reservoir is a short 19 days, and Vollenweider's model probably is not applicable.

2. Non-point sources--Non-point sources, including direct precipitation, added 99.9% of the total phosphorus load to the reservoir during the sampling year. The Stanislaus River contributed 92.4% of the total load; Black Creek, 0.5%; and the ungaged tributaries, an estimated 6.9%.

The phosphorus export rates of the Stanislaus River and Black Creek were 15 and 3 $kg/km^2/yr$, respectively (see page 10).

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 5.10 kilometers^2.
2. Mean depth: 16.5 meters.
3. Maximum depth: 62.5 meters.
4. Volume: 84.371 x 10^6 m^3.
5. Mean hydraulic retention time: 19 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Stanislaus River	2,343.9	49.840
Black Creek	49.5	0.242
Minor tributaries & immediate drainage -	134.8	1.508
Totals	2,528.2	51.590**

2. Outlet -

Stanislaus River	2,533.3**	51.590

C. Precipitation***:

1. Year of sampling: 89.7 centimeters.
2. Mean annual: 81.1 centimeters.

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† Table of metric conversions--Appendix B.
†† Dendy, 1974.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir; inflows adjusted to equal outflow.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Tullock Reservoir was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 45.1 meters at station 1, 35.4 meters at station 2, and 32.3 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR TULLOCK RESERVOIR
STORET CODE 0624

PARAMETER	1ST SAMPLING (3/14/75) 3 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (6/25/75) 3 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (11/12/75) 3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	4.7 - 10.8	9.0	8.7	12.6 - 20.3	16.1	14.3	13.7 - 14.7	14.3	14.4
DISS OXY (MG/L)	9.4 - 12.0	10.9	11.0	8.4 - 10.0	9.3	9.2	7.6 - 10.8	9.6	10.2
CNDCTVY (MCROMO)	57. - 84.	69.	67.	28. - 63.	34.	32.	71. - 89.	79.	79.
PH (STAND UNITS)	7.5 - 9.0	8.2	7.8	7.2 - 7.9	7.5	7.5	7.5 - 8.3	7.8	7.8
TOT ALK (MG/L)	41. - 51.	46.	46.	19. - 24.	22.	22.	30. - 39.	33.	32.
TOT P (MG/L)	0.015 - 0.056	0.029	0.029	0.014 - 0.185	0.031	0.023	0.016 - 0.041	0.027	0.027
ORTHO P (MG/L)	0.009 - 0.020	0.014	0.014	0.003 - 0.016	0.007	0.006	0.002 - 0.012	0.005	0.005
NO2+NO3 (MG/L)	0.020 - 0.160	0.051	0.040	0.020 - 0.030	0.020	0.020	0.020 - 0.150	0.068	0.060
AMMONIA (MG/L)	0.020 - 0.070	0.028	0.020	0.030 - 0.060	0.037	0.030	0.020 - 0.070	0.032	0.020
KJEL N (MG/L)	0.200 - 0.500	0.264	0.200	0.200 - 0.500	0.257	0.200	0.200 - 0.300	0.208	0.200
INORG N (MG/L)	0.040 - 0.220	0.080	0.060	0.050 - 0.080	0.057	0.050	0.040 - 0.200	0.100	0.080
TOTAL N (MG/L)	0.220 - 0.520	0.315	0.300	0.220 - 0.520	0.278	0.220	0.220 - 0.360	0.275	0.260
CHLRPYL A (UG/L)	14.0 - 15.6	14.8	14.9	0.2 - 4.5	3.0	4.4	3.2 - 64.2	23.8	3.9
SECCHI (METERS)	1.2 - 1.3	1.2	1.2	1.8 - 2.7	2.3	2.4	1.2 - 2.0	1.5	1.4

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/14/75	1. Achananthes sp.	3,864
	2. Asterionella sp.	2,006
	3. Synedra sp.	1,783
	4. Stephanodiscus sp.	743
	5. Cryptomonas sp.	297
	Other genera	744
	Total	9,437
06/25/75	1. Asterionella sp.	432
	2. Stephanodiscus sp.	118
	3. Fragilaria sp.	79
	4. Oscillatoria sp.	79
	5. Dinobryon sp.	79
	Other genera	195
	Total	982
11/12/75	1. Oscillatoria sp.	225
	2. Glenodinium sp.	112
	3. Asterionella sp.	37
	4. Cryptomonas sp.	37
	5. Stephanodiscus sp.	37
	Other genera	113
	Total	561

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
03/14/75	1	14.0
	2	15.6
	3	14.9
06/25/75	1	4.5
	2	4.4
	3	0.2
11/12/75	1	3.9
	2	3.2
	3	64.2

C. Limiting Nutrient Study:

The algal assay results are not considered representative of conditions in the reservoir at the time of sample collection because of significant changes in the nutrients in the samples during shipment from the field to the laboratory.

The reservoir data indicate nitrogen limitation in March and June and phosphorus limitation in November. The mean inorganic nitrogen to orthophosphorus ratios were 6 to 1 in March, 8 to 1 in June, and 20 to 1 in November.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the California National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v). Sampling was begun in November, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the California District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Green Spring Run at station B-1 and the mean annual ZZ flow.

No known wastewater treatment plants impacted Tullock Reservoir during the sampling year.

A. Waste Sources:

1. Known municipal - None

2. Known municipal - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Stanislaus River	34,580	92.4
Black Creek	170	0.5
b. Minor tributaries & immediate drainage (non-point load) -	2,570	6.9
c. Known municipal STP's - None	-	-
d. Septic tanks* -	10	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	90	0.2
Total	37,420	100.0

2. Outputs -

Reservoir outlet - Stanislaus River 32,540

3. Net annual P accumulation - 4,880 kg.***

* Estimate based on 40 shoreline dwellings; see Working Paper No. 175.
** See Working Paper No. 175.
*** The phosphorus "loss" shown in the preliminary report resulted from the inclusion of an erroneous value (0.120 mg/l on 05/12/75) in the calculation of the outlet load at station A-1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Stanislaus River	1,439,725	94.2
Black Creek	11,240	0.7
b. Minor tributaries & immediate drainage (non-point load) -	72,050	4.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	425	< 0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	5,505	0.4
Total	1,528,945	100.0

2. Outputs -

Reservoir outlet - Stanislaus River 1,506,550

3. Net annual N accumulation - 22,395 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Stanislaus River	15	614
Black Creek	3	227

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Green Spring Run	0.054	1.515

* Estimate based on 40 shoreline dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	7.34	0.96	299.8	4.4

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Tullock Reservoir:

"Dangerous" (eutrophic loading)	3.40
"Permissible" (oligotrophic loading)	1.70

V. LITERATURE REVIEWED

Allum, M.O., R.E. Glessner, and J.H. Gakstatter, 1977. An evaluation of the National Eutrophication Survey data. Corvallis Env. Res. Lab., Corvallis, OR.

Dendy, William B., 1974. Personal communication (waterbody information and morphometry). CA Water Res. Contr. Bd., Sacramento.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLOPA	15-MIN DO	MEDIAN DISS ORTHO P
0601	AMADOR RESERVOIR	0.040	0.390	408.667	22.383	14.600	0.020
0602	BOCA LAKE	0.012	0.040	372.833	1.700	6.800	0.003
0603	LAKE BRITTON	0.067	0.115	448.500	4.811	11.200	0.047
0604	CASITAS RESERVOIR	0.029	0.050	400.250	3.192	14.000	0.014
0605	CROWLEY LAKE	0.048	0.045	374.750	5.800	12.200	0.034
0606	DON PEDRO RESERVOIR	0.013	0.060	381.733	3.564	11.400	0.004
0607	LAKE ELSINORE	0.469	0.120	489.214	70.572	8.000	0.092
0608	FALLEN LEAF RESERVOIR	0.007	0.040	24.357	0.786	8.800	0.005
0609	LAKE HENNESSEY	0.027	0.060	416.000	4.525	15.000	0.012
0610	LAKE HENSHAW	0.138	0.070	461.000	26.783	9.800	0.073
0611	IRON GATE RESERVOIR	0.184	0.690	440.333	6.217	13.800	0.124
0614	LOPEZ LAKE	0.371	0.090	372.000	8.658	15.000	0.343
0615	LAKE MARY	0.010	0.040	296.000	2.550	10.600	0.002
0616	LAKE MENDOCINO	0.020	0.050	436.500	3.100	9.400	0.008
0617	NICASIO RESERVOIR	0.055	0.345	482.778	6.633	9.800	0.013
0618	LOWER OTAY RESERVOIR	0.058	0.180	447.250	15.933	15.000	0.013
0619	LAKE PILLSBURY	0.022	0.060	466.667	6.389	8.200	0.008
0620	SANTA MARGARITA LAKE	0.037	0.070	400.000	9.122	14.800	0.014
0621	SHASTA LAKE	0.021	0.060	381.542	4.087	9.000	0.015
0622	SHAVER	0.014	0.060	346.400	1.700	7.400	0.004
0623	SILVER LAKE	0.012	0.055	356.000	1.800	7.000	0.003
0624	TULLOCK RESERVOIR	0.025	0.060	433.000	13.878	7.400	0.009
0625	UPPER TWIN LAKES	0.015	0.040	300.200	3.340	7.400	0.004
0626	LOWER TWIN LAKES	0.014	0.040	248.000	2.900	11.400	0.003

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
0601	AMADOR RESERVOIR	35 (8)	4 (1)	43 (10)	9 (2)	17 (4)	26 (6)	134
0602	BOCA LAKE	89 (20)	98 (22)	70 (16)	91 (21)	100 (23)	91 (20)	539
0603	LAKE BRITTON	17 (4)	22 (5)	17 (4)	48 (11)	43 (10)	17 (4)	164
0604	CASITAS RESERVOIR	43 (10)	74 (17)	48 (11)	70 (16)	22 (5)	37 (8)	294
0605	CROWLEY LAKE	30 (7)	78 (18)	65 (15)	43 (10)	30 (7)	22 (5)	268
0606	DON PEDRO RESERVOIR	83 (19)	54 (11)	57 (13)	61 (14)	37 (8)	78 (17)	370
0607	LAKE ELSINORE	0 (0)	17 (4)	0 (0)	0 (0)	78 (18)	9 (2)	104
0608	FALLEN LEAF RESERVOIR	100 (23)	87 (19)	100 (23)	100 (23)	70 (16)	70 (16)	527
0609	LAKE HENNESSEY	48 (11)	54 (11)	39 (9)	52 (12)	4 (0)	52 (12)	249
0610	LAKE HENSHAW	13 (3)	33 (7)	13 (3)	4 (1)	54 (12)	13 (3)	130
0611	IRON GATE RESERVOIR	9 (2)	0 (0)	26 (6)	39 (9)	26 (6)	4 (1)	104
0614	LOPEZ LAKE	4 (1)	26 (6)	74 (17)	26 (6)	4 (0)	0 (0)	134
0615	LAKE MARY	96 (22)	87 (19)	91 (21)	83 (19)	48 (11)	100 (23)	505
0616	LAKE MENDOCINO	65 (15)	70 (16)	30 (7)	74 (17)	61 (14)	63 (14)	363
0617	NICASIO RESERVOIR	26 (6)	9 (2)	4 (1)	30 (7)	54 (12)	46 (10)	169
0618	LOWER OTAY RESERVOIR	22 (5)	13 (3)	22 (5)	13 (3)	4 (0)	46 (10)	120
0619	LAKE PILLSBURY	57 (13)	41 (9)	9 (2)	35 (8)	74 (17)	63 (14)	279
0620	SANTA MARGARITA LAKE	39 (9)	33 (7)	52 (12)	22 (5)	13 (3)	37 (8)	196
0621	SHASTA LAKE	61 (14)	54 (11)	61 (14)	57 (13)	65 (15)	30 (7)	328
0622	SHAVER	78 (18)	41 (9)	83 (19)	96 (22)	87 (19)	78 (17)	463
0623	SILVER LAKE	89 (20)	65 (15)	78 (18)	87 (20)	96 (22)	91 (20)	506
0624	TULLOCK RESERVOIR	52 (12)	54 (11)	35 (8)	17 (4)	87 (19)	57 (13)	302
0625	UPPER TWIN LAKES	70 (16)	98 (22)	87 (20)	65 (15)	87 (19)	78 (17)	485
0626	LOWER TWIN LAKES	74 (17)	87 (19)	96 (22)	78 (18)	37 (8)	91 (20)	463

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	0602	BOCA LAKE	539
2	0608	FALLEN LEAF RESERVOIR	527
3	0623	SILVER LAKE	506
4	0615	LAKE MARY	505
5	0625	UPPER TWIN LAKES	485
6	0626	LOWER TWIN LAKES	463
7	0622	SHAVER	463
8	0606	DON PEDRO RESERVOIR	370
9	0616	LAKE MENDOCINO	363
10	0621	SHASTA LAKE	328
11	0624	TULLOCK RESERVOIR	302
12	0604	CASITAS RESERVOIR	294
13	0619	LAKE PILLSBURY	279
14	0605	CROWLEY LAKE	268
15	0609	LAKE HENNESSEY	249
16	0620	SANTA MARGARITA LAKE	196
17	0617	NICASIO RESERVOIR	169
18	0603	LAKE BRITTON	164
19	0614	LOPEZ LAKE	134
20	0601	AMADOR RESERVOIR	134
21	0610	LAKE HENSHAW	130
22	0618	LOWER OTAY RESERVOIR	120
23	0607	LAKE ELSINORE	104
24	0611	IRON GATE RESERVOIR	104

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107 x 10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 - cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR CALIFORNIA 12/02/76

LAKE CODE 0624 TULLOCH RESERVOIR

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 2533.3

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
0624A1	2533.3	76.46	57.20	62.01	67.68	99.68	84.67	47.01	42.48	32.28	14.27	8.13	27.30	51.59
0624A2	2343.9	34.63	40.50	39.57	75.75	116.25	109.14	55.03	40.81	26.12	12.99	12.52	34.63	49.84
0624C1	49.5	0.906	0.623	0.566	0.283	0.085	0.034	0.011	0.003	0.003	0.006	0.062	0.340	0.242
0624ZZ	139.9	5.267	3.483	3.256	1.727	0.481	0.187	0.071	0.017	0.023	0.045	0.368	1.869	1.391

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 2533.3
SUM OF SUB-DRAINAGE AREAS = 2533.3
TOTAL FLOW IN = 617.64
TOTAL FLOW OUT = 619.15

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0624A1	11	74	14.781	16	18.434				
	12	74	21.436	7	31.432				
	1	75	2.124	12	2.350				
	2	75	46.156	8	47.289				
	3	75	47.572	15	54.085				
	4	75	50.121	19	49.271				
	5	75	111.852	12	108.454				
	6	75	128.558	1	226.252				
	7	75	51.820						
	8	75	45.873	24	41.343				
	9	75	33.697	30	30.299				
	10	75	30.865						
0624A2	11	74	13.337	16	20.388				
	12	74	12.856	7	20.530				
	1	75	9.175	11	18.123				
	2	75	34.830	8	42.475				
	3	75	40.493	15	39.927				
	4	75	41.909	19	41.909				
	5	75	143.566	10	122.329				
	6	75	129.408	1	260.232				
	7	75	49.271						
	8	75	42.758	24	42.192				
	9	75	25.995	30	14.158				
	10	75	19.199						

TRIBUTARY FLOW INFORMATION FOR CALIFORNIA 12/02/76

LAKE CODE 0624 TULLOCH RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0624C1	11	74	0.040	16	0.023				
	12	74	0.227	7	0.184				
	1	75	0.340	12	0.340				
	2	75	1.133	8	0.736				
	3	75	1.246	15	0.198				
	4	75	0.453	19	0.425				
	5	75	0.085	10	0.113				
	6	75	0.028	1	0.042				
	7	75	0.003						
	8	75	0.0	24	0.0				
	9	75	0.0	30	0.0				
	10	75	0.0						
0624ZZ	11	74	0.229						
	12	74	1.274						
	1	75	1.841						
	2	75	6.428						
	3	75	7.136						
	4	75	2.265						
	5	75	0.566						
	6	75	0.142						
	7	75	0.042						
	8	75	0.014						
	9	75	0.014						
	10	75	0.028						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/09/24

062401
37 52 38.0 120 36 10.0 3
TULLOCK RESERVOIR
06109 CALIFORNIA
141091

11EPALES 2111202
0152 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/14	09 55	0000	10.4	12.0	48	70	8.90	47	0.020	0.500	0.020K	0.009
	09 55	0005	10.4			71	8.90	46	0.020	0.300	0.020K	0.011
	09 55	0015	10.3	11.8		70	8.10	43	0.020K	0.400	0.020K	0.013
	09 55	0025	9.0	10.2		65	7.80	44	0.020	0.200	0.040	0.011
	09 55	0050	8.7	10.4		61	7.80	41	0.030	0.200	0.040	0.020
	09 55	0080	8.4	11.0		61	7.75	42	0.030	0.200	0.050	0.020
	09 55	0110	7.9	10.6		65	7.70	44	0.030	0.200K	0.090	0.012
	09 55	0148	7.4	10.0		66	7.60	44	0.070	0.200	0.110	0.017
75/06/25	14 15	0000	19.4	9.2	96	36	7.60	19	0.050	0.300	0.030	0.004
	14 15	0005	19.2	9.2		32	7.95	21	0.030	0.200	0.020K	0.003
	14 15	0010	18.6	9.4		30	7.80	21	0.040	0.300	0.020	0.007
	14 15	0020	14.1	9.8		28	7.55	23	0.030	0.200	0.020K	0.005
	14 15	0040	13.7	9.4		31	7.40	22	0.030	0.200	0.020K	0.005
	14 15	0060	13.5	9.6		29	7.30	23	0.040	0.200K	0.020K	0.005
	14 15	0080	13.0	9.0		31	7.25	20	0.050	0.200	0.020K	0.005
75/11/12	11 00	0000	14.7	10.2	78	74	8.30	32	0.020K	0.200K	0.020K	0.004
	11 00	0005	14.4	10.2		73	8.20	32	0.020K	0.200K	0.020K	0.004
	11 00	0016	14.3	10.2		73	8.05	33	0.020K	0.200K	0.050	0.003
	11 00	0030	14.2	10.0		71	8.00	33	0.020K	0.200K	0.020	0.002
	11 00	0058	13.7	8.6		71	7.80	39	0.040	0.200K	0.150	0.006

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

062401
37 52 38.0 120 36 10.0 3
TULLOCK RESERVOIR
06109 CALIFORNIA
141091

11EPALES 2111202
0152 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/14	09 55	0000	0.034	14.0	
	09 55	0005	0.034		
	09 55	0015	0.033		
	09 55	0025	0.036		
	09 55	0050	0.034		
	09 55	0080	0.041		
	09 55	0110	0.015		
	09 55	0148	0.020		
75/06/25	14 15	0000	0.018	4.5	
	14 15	0005	0.016		
	14 15	0010	0.015		
	14 15	0020	0.014		
	14 15	0040	0.015		
	14 15	0060	0.015		
	14 15	0080	0.016		
75/11/12	11 00	0000	0.018	3.9	
	11 00	0005	0.016		
	11 00	0016	0.017		
	11 00	0030	0.020		
	11 00	0058	0.025		

STORET RETRIEVAL DATE 76/09/24

062402
37 54 03.0 120 35 12.0 3
TULLOCK RESERVOIR
06009 CALIFORNIA
141091

11EPALES 2111202
0111 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/14	10 55	0000	10.8	11.8	48	82	9.00	48	0.020K	0.500	0.020K	0.014
	10 55	0005	10.7	11.8		80	8.95	48	0.020K	0.400	0.020K	0.012
	10 55	0015	10.6	10.2		78	8.75	49	0.020	0.300	0.020K	0.019
	10 55	0035	8.7	11.0		60	7.95	42	0.020	0.200K	0.040	0.014
	10 55	0060	8.5	10.6		65	7.80	44	0.030	0.200K	0.060	0.014
	10 55	0085	8.4	9.8		84	7.60	51	0.040	0.200K	0.150	0.011
	10 55	0107	8.1	9.4		80	7.50	51	0.060	0.200K	0.160	0.013
75/06/25	14 55	0000	20.3	10.0	108	37	7.70	22	0.040	0.200	0.020K	0.006
	14 55	0005	19.9	9.2		35	7.70	20	0.040	0.300	0.020K	0.005
	14 55	0010	18.1	9.2		38	7.80	21	0.040	0.200K	0.020K	0.004
	14 55	0020	14.3	9.8		34	7.40	22	0.030	0.200	0.020K	0.009
	14 55	0040	13.9	9.2		63	7.40	20	0.030	0.200	0.020K	0.016
	14 55	0080	13.0	9.0		32	7.30	22	0.040	0.300	0.020	0.015
	14 55	0116	12.6	8.4		34	7.20	23	0.060	0.300	0.020	0.013
75/11/12	10 20	0000	14.5	10.2	48	89	7.70	33	0.030	0.300	0.060	0.005
	10 20	0005	14.4	9.4		89	7.60	32	0.020K	0.200	0.080	0.003
	10 20	0015	14.3	7.8		83	7.50	33	0.060	0.200K	0.100	0.012
	10 20	0031	14.0	7.6		81	7.50	30	0.070	0.200K	0.120	0.006

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/14	10 55	0000	0.032	15.6	
	10 55	0005	0.029		
	10 55	0015	0.031		
	10 55	0035	0.017		
	10 55	0060	0.017		
	10 55	0085	0.017		
	10 55	0107	0.025		
75/06/25	14 55	0000	0.016	4.4	
	14 55	0005	0.019		
	14 55	0010	0.019		
	14 55	0020	0.031		
	14 55	0040	0.025		
	14 55	0080	0.061		
	14 55	0116	0.035		
75/11/12	10 20	0000	0.041	3.2	
	10 20	0005	0.028		
	10 20	0015	0.034		
	10 20	0031	0.034		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

062403
37 53 38.0 120 34 19.0 3
TULLOCK RESERVOIR
06109 CALIFORNIA
141091

11EPALES 2111202
0110 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/14	11 50	0000	10.4	12.0	48	74	8.95	48	0.020K	0.300	0.020K	0.013
	11 50	0005	10.4	11.6		75	8.90	49	0.020K	0.300	0.020K	0.013
	11 50	0015	10.0	11.8		68	8.40	47	0.020K	0.200K	0.020K	0.016
	11 50	0035	8.7	11.0		57	7.90	41	0.020K	0.200K	0.030	0.014
	11 50	0060	6.5	11.0		57	7.75	42	0.020	0.200K	0.040	0.017
	11 50	0085	8.1	10.6		64	7.70	47	0.030	0.200K	0.060	0.016
	11 50	0106	4.7	10.4		64	7.70	46	0.040	0.200K	0.080	0.016
75/06/25	15 30	0000	20.3	9.2	72	36	7.80	23	0.030	0.300	0.020K	0.009
	15 30	0005	20.3	9.0		32	7.75	24	0.030	0.300	0.020K	0.008
	15 30	0010	19.3	9.4		35	7.75	22	0.030	0.300	0.020K	0.009
	15 30	0020	14.4	9.8		30	7.50	23	0.030	0.300	0.020K	0.008
	15 30	0040	13.6	9.2		33	7.40	23	0.030	0.200K	0.020K	0.004
	15 30	0060	13.6	9.2		31	7.35	22	0.030	0.200K	0.020K	0.004
	15 30	0086	12.8	9.2		31	7.25	23	0.040	0.500	0.020	0.012
75/11/12	10 45	0000	14.6	10.8	57	79	7.90	32	0.020K	0.200K	0.030	0.005
	10 45	0005	14.5	10.8		79	7.90	32	0.020K	0.200K	0.030	0.008
	10 45	0015	14.4	10.2		81	7.85	32	0.020K	0.200K	0.060	0.003
	10 45	0028	14.1	9.0		81	7.70	38	0.060	0.200K	0.140	0.006

DATE FROM TO	TIME OF DAY	DEPTH FEET	03665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/14	11 50	0000	0.056	14.9	
	11 50	0005	0.050		
	11 50	0015	0.022		
	11 50	0035	0.029		
	11 50	0060	0.026		
	11 50	0085	0.017		
	11 50	0106	0.022		
75/06/25	15 30	0000	0.027	0.2	
	15 30	0005	0.026		
	15 30	0010	0.025		
	15 30	0020	0.023		
	15 30	0040	0.023		
	15 30	0060	0.025		
	15 30	0086	0.186		
75/11/12	10 45	0000	0.027	64.2	
	10 45	0005	0.036		
	10 45	0015	0.025		
	10 45	0028	0.027		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/09/24

062-A1
37 52 34.0 120 36 12.0 4
STANISLAUS RIVER
06 15 COPPEROPOLIS
O/TULLOCH LAKE 141091
BNK BELO DAM 5.5 MI NE OF KNIGHTS FERRY
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/16	12	38	0.048	1.200	0.055	0.005K	0.010
74/12/07	12	35	0.040	1.000	0.055	0.005	0.010
75/01/12	11	40	0.088	0.400	0.010	0.005K	0.010K
75/02/08	10	45	0.104	1.500	0.016	0.015	0.040
75/03/15	10	30	0.065	0.900	0.024	0.010	0.020
75/04/14	10	15	0.045	1.300	0.040	0.015	0.020
75/05/12	17	30	0.040	1.200	0.030	0.005K	
75/06/01	13	15	0.010	0.050	0.020	0.005	0.030
75/08/24	10	00	0.050	0.400	0.035	0.005	0.010K
75/09/30	19	05	0.025	0.800	0.040	0.005K	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

062442
37 56 50.0 120 31 45.0 4
STANISLAUS RIVER
06 IS COPPEROPOLIS
T/TULLOCH LAKE 141091
BNK / MI E OF COPPEROPOLIS
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/18	14 30		0.040	0.700	0.055	0.005K	0.020
74/12/07	10 00		0.160	1.600	0.035	0.015	0.030
75/01/11	09 00		0.071	1.600	0.025	0.005	0.020
75/02/08	11 45		0.048	0.900	0.016	0.010	0.020
75/03/15	09 55		0.040	0.300	0.010	0.010	0.030
75/04/19	09 00		0.020	1.400	0.025	0.005	0.020
75/05/10	10 50		0.010	0.150	0.025	0.005	0.010
75/06/01	11 45		0.015	0.600	0.025	0.005	0.020
75/08/24	11 54		0.020	0.850	0.080	0.005	0.010K
75/09/30	20 10		0.040	0.600	0.035	0.005	0.040

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

062481
37 52 15.0 120 32 40.0 4
GREENSPRING RUN
06 15 COPPEROPOLIS
T/TULLOCH LAKE 141091
UNPVD RD BRDG 2 MI NW OF HWY 120 JCT
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/16	11 45		1.056	2.000	0.050	0.025	0.030
74/12/07	12 05		1.010	2.000	0.040	0.055	0.060
75/01/12	10 50		0.680	1.050	0.005	0.045	0.050
75/04/19			0.300	1.000	0.030	0.090	0.100
75/05/10	14 25		0.220	0.650	0.035		0.030
75/08/24	10 35		0.020	0.700	0.065	0.045	0.060
75/09/30	18 30		0.020	0.900	0.050	0.020	0.050

STORET RETRIEVAL DATE 76/09/24

062+C1
37 55 50.0 120 37 05.0 4
BLACK CREEK
06 15 COPPEROPOLIS
T/TULLOCH LAKE 141091
BNK .2 M SW RD 4.2 MI SE OF COPPEROPOLIS
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/16	10	35	0.112	0.200	0.020	0.005K	0.010K
74/12/07	10	30	2.160	1.000	0.030	0.015	0.015
75/01/12	10	00	1.160	0.850	0.015	0.005	0.010K
75/02/08	09	40	0.552	1.000	0.008K	0.005	0.020
75/03/15	09	20	0.284	0.900	0.015	0.010	0.010
75/04/19	08	30	0.195	1.530	0.027	0.025	0.025
75/05/10	13	20	0.155	0.950	0.095		0.054
75/06/01	12	30	0.035	0.700	0.260	0.015	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED